MINISTRY OF THE ENVIRONMENT
135 ST. CLAIR AVENUE WEST
TORONTO 195, ONTARIO

ONTARIO

QUANTITY AND QUALITY OF WEEPING TILE FLOW

Maria Schouten
Research Branch

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Research paper

R.P.W2033

ABSTRACT

This report is prepared for the joint committee of the City Engineers Association of Ontario and the Ontario Ministry of the Environment. It outlines the general problem of flow from weeping tile into sanitary sewers and presents and analyses data from measurements taken to assess the quantity and quality of water collected by weeping tile. Conclusions are drawn and a general discussion on remedial measurements is also included.

ACKNOWLEDGMENTS

The cooperation of the owners of the houses where installations were located is greatly appreciated. The services of Mr. J. MacNamara and his staff from the Water Pollution Control Plant in Niagara Falls and staff from the plant in Guelph, who operated the equipment, are also acknowledged. The equipment was loaned for the duration of the study by the Division of Building Research of the National Research Council who also provided valuable information about sites where the equipment had been tested.

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1. Introduction

Need for sewage disposal and sewage treatment and the growing costs associated with it have made it necessary in recent years to examine closely the sources of flow into sanitary sewers.

The following types of flow can be found in a sanitary sewer:

a. Wastewater discharged from residential, commercial and industrial sites,

b. Groundwater infiltrating into the sewer lines,

c. Stormwater reaching the sewer lines from weeping tile, downspouts, yard drains and leakage of manholes.

The first one (a), called dry weather flow, can be calculated for design purposes by knowing the projected number of people and types of industries connected to the sewer. Extra provision must be made when cooling waters are allowed to be discharged into the sanitary sewer. Infiltration occurs at faulty joints in the sewer lines or at connections between house lines and sewer lines. The amount of water infiltrating varies widely but can be as high as 2,340,000 liters per day per km, (833,000 IGPD per mile) of sewer for short stretches when the system is below groundwater (1). No design figures are given for this type of flow, although often a figure of 70 liters per sec per ha. (0.0024 cfs per acre) is used in Ontario (2).

Improvement of connection seals and carefully checking of the sewer lines will decrease the amount of this type of flow.

Downspout connections provide large amounts of flow. A rainfall of 25 mm (1") on a roof of 92.9 m^2 (1000 sq. ft.) can contribute 2320 liters (520 IG) to the sewer.

Weeping tile can also contribute a considerable amount of flow when connected to the sanitary sewer. A study carried out in Johnson County, Kansas, showed that the flow could be as high as 37,850 liters per day (8,330 IGPD) for one house after a rainstorm of 10.2 cm (4") (3). Again no design figures are given for weeping tile flow and a separate evaluation for each sewer system must be made. An average of 6800 liters (1600 IG) per day per house has been used in Kansas City, Mo. (1).

Weeping tile collects excess water in the ground, caused by rainfall or snowmelt. Its purpose is to prevent damp basements and cracking of basement floors. Either a sump collects the water and from there it is pumped into a sewer, or the water is drained directly into a sewer, usually the sanitary sewer since its location is often lower than the storm sewer. Water infiltrates into the soil, but the rate of infiltration is different for each type of soil dependent upon the physical characteristics of the soil, upon its initial

moisture content, upon the type of vegetation, slope of the surface, frost conditions in the soil, presence of snowcover, etc. It is also dependent upon the rainfall characteristics. With continuing rainfall the rate of infiltration will reach a steady state, the soil will become saturated and flow towards the weeping tile will take place.

It is difficult to make estimates of the amount of flow since the weeping tile cannot be regarded as a drain tile used for agricultural purposes. Methods for estimating flow for field drain tile are given in the literature, (4,5,6). Weeping tile consists of one row of tile usually outside the foundation. The area contributing is difficult to estimate. Downspouts can provide a large amount of water on concentrated spots. If the soil is not completely sealed against the walls, rainwater can reach the weeping tile quickly along the walls. Heat exchange with the house will prevent the soil adjacent to the house from freezing for some time thus giving a different condition in comparison with the surrounding area.

In general the steady state, necessary to start flow, is reached quickly with a rainfall of high intensity or when the soil is still partly saturated from a previous rainfall. Seasonal factors like temperatures and evaporation will also influence the amount of water available for infiltration.

Rainwater that does not or cannot infiltrate will form surface runoff or depression storage. When the rain has stopped flow will usually continue for some time, lowering water levels in the vicinity and decreasing the amount of water stored in the soil. In the winter and spring, melting of snow on roofs and on the ground will provide additional sources of water.

Usually infiltration and flow from weeping tile will be at a maximum shortly after a rainfall, thus causing heavy hydraulic loading of the sewers and treatment plants, which are often forced to bypass parts of the flow.

Policies regarding connections of weeping tile to the sanitary sewer differ from city to city, often as a result of the historical growth of the sewer system. In Ottawa, for example, properties developed after 1961 have not been allowed to connect weeping tile to the sanitary sewer (By-law no. 98-61). In the city of Toronto weeping tile flow may be discharged into the combined sewer. When a separate sewer system is present, weeping tile flow drained by gravity normally discharges into the sanitary sewer and if pumped must discharge into the storm sewer. This policy reflects the fear of back-up of the storm sewer into basements.

The Burroughs of North York and East York in Metropolitan Toronto drain weeping tile into the sanitary sewer.

Roof drainage flows directly into the storm sewer. In Etobicoke and Scarborough weeping tile flow cannot be discharged into the sanitary sewer (By-law 402 and 12293). In Niagara Falls there exists no written policy and every request for connection to the sanitary sewer is considered separately.

Not much is known about the amount of flow weeping tile can contribute to the sanitary sewer under different circumstances in Ontario. A study in Sault Ste. Marie, carried out to evaluate the "extraneous flow" contribution to the sanitary sewer, approached the problem on an area-basis. It was tentatively concluded that weeping tile could contribute a considerable amount in areas with sandy subsoil and a high water table (2). A second study done in that city also showed a large amount of extraneous flow due to the connection of weeping tile to the sanitary sewer in certain areas. (7)

The study, presented in this report, investigated the flow from weeping tile by measuring at several locations rainfall and the corresponding flow from weeping tile. The program was initiated in December 1969 when measurements were taken at a house in Niagara Falls. Four sites were added since that time.

The object of the program was to gather information on amount of weeping tile flow at sites which differ in soil type, backfill, weeping tile, roof drainage, and other factors

that may affect weeping tile flow. This report presents the analysis of the data, collected at five sites; two in Niagara Falls; one in Guelph; one in Grimsby; one in Smithville. All sites have a tip-bucket raingauge on the roof and a pump with a timing device in the basement. Data obtained from two houses in the Ottawa area where the equipment was originally tested, have been used for additional information.

2. Equipment and Data Collection

The following measurements are made on each site:

a) Amount of Rainfall

The rainfall was measured in a tip-bucket raingauge which was located on the roof of the house. Each raingauge is calibrated separately, but one tip represents approximately 0.25 mm (0.01") of rain. Each tip is recorded on a recorder chart providing a continuous record of amount of rain over a period of time. Very heavy rainstorms cannot be recorded accurately, since the tipping mechanism cannot keep up with the rain falling in the bucket. Figure 1 shows a tip-bucket raingauge on the roof of one of the houses in Niagara Falls.

b) Discharge of the basement sump pump

Flow from the weeping tile at all installations is collected in a sump in the basement. A pump discharges the water from the sump into the connector to the sewer. The discharge of the pump for an operation time of one minute is calibrated. Each one-minute operation time of the pump, measured with a time mechanism, is also recorded on the chart mentioned above. The one-minute operation time can be spread over several operating cycles.

Thus for each site there are available charts containing records of rainfall as shown by the number of tips of the tip-bucket raingauge, and the number of minutes of

operation time of the sump pump. Figure 2 shows a setup of a recorder in one of the basements. The equipment was tested during the summer of 1968 and 1969 at two sites near Ottawa and proved to be working properly. The weather records kept at the Stamford - Niagara Falls Water Pollution Control Plant were obtained to provide information about temperature and snowfall, which cannot be measured properly with the raingauge.

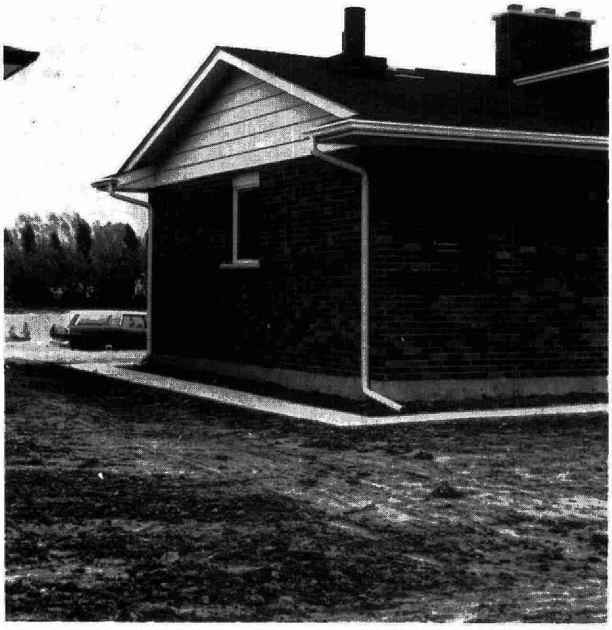
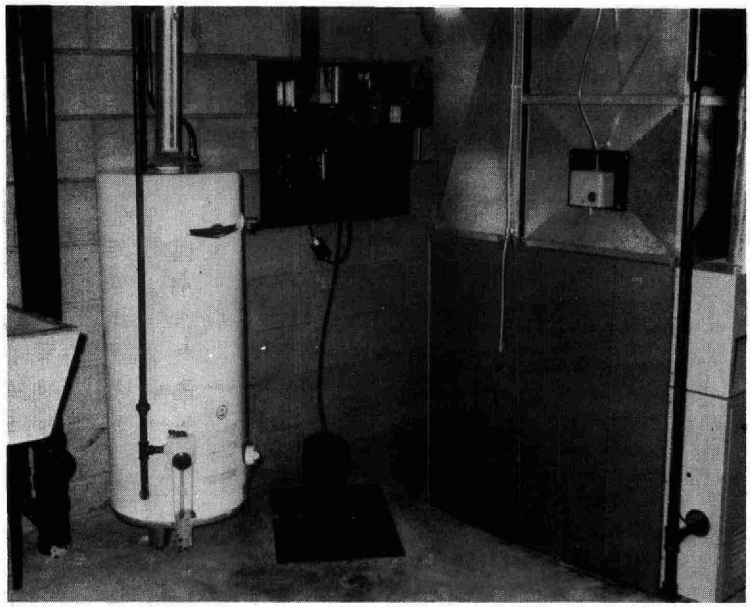


FIGURE 1: Raingauge on roof of house # 2
in Niagara Falls



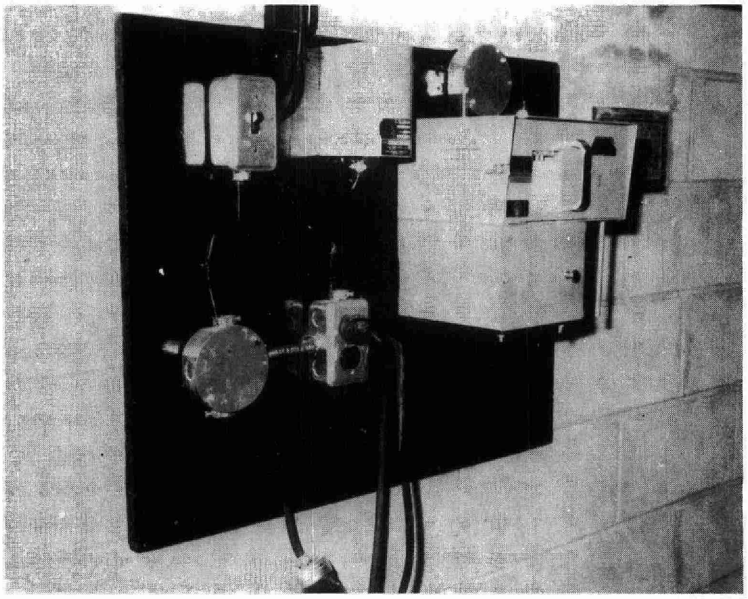


FIGURE 2: Sump pump and recorder set up in the basement of house # 1 in Niagara Falls

3. Site Description

3.1 Niagara Falls #1 - Muir Avenue

The house is located in an older section of Niagara Falls and is approximately three years old. The downspout on the front side of the house discharges into the soil, the two downspouts at the back of the house are extended 1 m (3.3 ft.) into the backyard and discharge into small ditches made by the owner of the house. The sump is located in the back part of the basement. The soil around the house is a heavy clay with the front yard covered by a thin layer of sand without vegetation. The backyard consists of a lawn and a small vegetable garden. A thin layer of quicksand was noticed at the back of the house during construction. On the west side of the house is a crushed stone driveway.

Roof surface:	106 m^2 (1140 sq. ft.)
Backfill:	0.95 cm (3/8") crushed stone
Weeping tile:	10.2 cm (4") clay tile

The discharge of the sump pump in operation for one minute equalled 123 liters (27 IG) up till March, 1971; at that time an adjustment was needed and the discharge now equals 190 liters (43 IG). Period of observation: December 1969 to November 1971.

3.2 Niagara Falls #2 - Corwin Crescent

The house is located in a new section of the city and has recently been built. There are two downspouts at the front of the house and one at the back, all discharging above

the ground. The sump is located in the front part of the basement. The front yard is slightly sloping downwards toward the street. The backyard is also sloping away from the house and is adjacent to an asphalt parking lot which has a catch basin. The soil consists of a sandy clay. In general the houses in the area are built on good sand-gravel beds. A crushed stone driveway leads to the garage.

Roof surface:	118 m^2 (1275 sq. ft.)
Backfill:	0.95 cm (3/8") crushed stone
Weeping tile:	10.2 cm (4") plastic pipe

The discharge of the sump pump in operation for one minute equals 272 liters (60 IG). Period of observation: December 1970 to November 1971.

3.3 Guelph - Westminister Drive

The house is located in a fairly new section of the town and is about 6 years old. The area is serviced by a storm and a sanitary sewer. The downspouts are all connected to the storm sewer. The sump pump discharges also into the storm sewer. Around the house is a lawn with several flower beds. The front yard is sloping downwards toward the street. In front of the garage and on one side of the house is asphalt pavement. The soil around the house is clay.

Roof surface:	92 m^2 (1000 sq. ft.)
Backfill:	1.9 cm (3/4") washed stone
Weeping tile:	10.2 cm (4") clay tile

The discharge of the sump pump in operation for one minute equals 272 liters (60 IG). Period of observation: July 1970

to August 1971.

3.4 Grimsby - Patton Street

The house and the neighbouring houses are approximately 100 years old. Weeping tiles have been laid 30 years ago when the concrete floor in the basement was poured. The tiles are laid within the foundation. The sump, located in one of the corners at the front of the house, discharges into the sanitary sewer. One downspout near the sump also discharges directly into the sanitary sewer. Three other downspouts are extended approximately 3 m (10 ft.) into the yard. Soil is a heavy loam. The garden is planted mainly with grass. At one side of the house is a driveway. Along the front of the house runs a ditch which collects the surface runoff of the street.

Roof surface:	92 m^2 (1000 sq. ft.)
Weeping tile:	10.2 cm (4") clay tile

The discharge of the sump pump in operation for one minute equals 132 liters (29.2 IG). Period of observation: December 1970 to November 1971.

3.5 Smithville- Rural Road

The house is located in the country. It is approximately 4 years old. Sanitary sewage is collected in a septic tank. Three downspouts at the back of the house

collect roofwater into a cistern. The sump pump discharges into a pipe which flows into a small creek passing through the property. Soil is a heavy clay and the house is surrounded by a lawn.

Roof surface:	110 m^2 (1200 sq. ft.)
Backfill:	Sand
Weeping tile:	10.2 cm (4") clay tile

The discharge of the pump in operation for one minute equals 97 liters (21.3 IG). Period of observation: December 1970 to June 1971.

3.6 Ottawa sites

The equipment was tested at two houses in the Ottawa area, located on the same road, about 300 m (1000 ft.) apart. Both are the same size. Because of low-lying clay soil one owner excavated only 45 cm (18") for his basement and backfilled 1.65 m (5½ ft.) with pit-run gravel. The ground around the house slopes away. The other house was excavated 2.1 m (7 ft.) and backfilled with soil from the excavation. The house has roof drains extended into the yard; the second house has no provisions for roof drainage.

The records available are used to provide additional information, since they do not represent a continuous operation. Periods of operation: May to November 1968 and April to September 1969.

4. Analyses of Available Data

The available data for the five sites have been summarized and analyzed in the following way:

a) A summary has been made on a monthly basis presenting the number of tips of the raingauge and the number of minutes of operation time of the sump pump per hour. This summary provides an overall picture of rainfall and flow from weeping tile.

b) For each significant rain storm a separate summary has been made in the following way. The time of the first tip of the raingauge represents the start of the rainfall. (This is not exact, since it must have been raining for some time to make the first tip possible). The time of the first mark, representing one minute of operation-time of the pump, after the start of the rainfall, is considered to be the beginning of the weeping tile flow caused by that particular rainfall. (The first minute of operation-time does not have to be the result of the same storm, but the time mark is close enough to take it as the beginning of the flow). For each half hour after the start of the rainfall the number of tips of the raingauge and minutes of operation of the sump pump are given. The corresponding amount of rainfall and flow have been calculated. The rainfall during a storm is not always continuous. When the time period between two tips is more than six hours, the

rainfall is considered to belong to two different storms; the time of the last tip of each storm is taken as the end of the storm. The time of a pump mark after the rain has ended and which has not been followed by another mark for two hours is the end of the flow caused by that particular rainfall. This is fairly arbitrary in that long after that time the flow can be a result of the rainfall which has been stored in the ground. For an example of a summary of a rainstorm see Table I.

It should be pointed out that none of the records were complete. Sometimes the chart was not changed on time, ink had dried out and so on. For the purpose of this report only reliable data are used for analyses.

TABLE I — Summary of Rainfall and Flow from Weeping Tile for Niagara Falls #1, July 31, 1970

Rain started: 14.56 hrs. Ended 17.07 hrs.
Flow started: 15.48 hrs.

Time	Tips of Raingauge	Rainfall cm	Rainfall in	Cum.Rainfall cm	Cum.Rainfall in	Minutes Operation of Pump	Flow Liters	Flow Gals.	Cum. Flow Liters	Cum. Flow Gals.
14.56										
	12	0.36	0.132							
15.26				0.36	0.132					
	18	0.50	0.198			1	123	27		
15.56				0.86	0.330				123	27
	33	0.92	0.363			8	984	216		
16.26				1.78	0.693				1107	243
	3	0.08	0.033			6	738	162		
16.56				1.85	0.726				1845	405
	1	0.03	0.011			3	369	81		
17.26				1.83	0.737				2214	486
						1	123	27		
17.56									2337	513
						1	123	27		
18.26									2460	540
						1	123	27		
18.56									2583	567
19.26									2583	567
						1	123	27		
19.56									2606	584

Duration of Rain: 2 hrs. and 11 min.
Time between start of rainfall and beginning of flow: 52 min.
Computed flow for 2.5 cm (1") of rain: 3600 liters (795 IG).

5. Discussion of Results and Observations

5.1 Niagara Falls #1

From the summary 4(a), it will be noted that during the summer months flow is directly associated with rainfall. Each rainfall of 2.5 mm (0.1") within three hours is followed by a flow from the weeping tile. Rainfall less than 2.5 mm is not always followed by flow and probably infiltrates into the soil.

A more or less continuous flow is noticed when the ground and roof are snow covered and the temperature is high enough to cause snow melt. There is virtually no flow when the temperature drops well below freezing. Table II presents pertinent data for some storms during the period of observation. Presented are:

(1) date of occurrence, (2) total amount of rainfall,

(3) duration of the rain, (4) corresponding average intensity,

(6) total weeping tile flow in liters,

(7) period of total flow,

(8) time lapse between start of rainfall and beginning of flow.

Two more columns have been added: (5) represents the volume of water fallen on the roof as a result of the total rainfall and (9) presents the amount of flow if 25 mm (1") of rain had

fallen during each storm calculated by linear extrapolation of rainfall (2) and weeping tile flow (6).

The storm analysis shows that flow will start within two hours after the beginning of a rainfall of moderate rate. When the rate of fall* (intensity) is high, flow will start much sooner (often within 30 minutes). A very light rainfall produces flow after a much longer time lapse. The beginning of the flow usually coincides with a rainfall of approximately 2.5 mm (0.1"). Most of the water, given as roof-volume in column (5) of Table II, will reach the soil through the downspouts, supplying large amounts of water to small areas. Part of this water forms surface-runoff. Through extension of downspouts into the soil, the water can reach the weeping tile very quickly. From Table II, the total flow is more than the roof-volume indicating that a larger area is contributing to the flow. For a few storms in the summer the total flow is less than the roof-volume. Infiltration and evaporation will have a greater impact in the summer months. The extrapolation column (9) tends to show a lower figure for

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* CLASSIFICATION OF RAINFALL BY THE ATMOSPHERIC ENVIRONMENT SERVICE

Light Rate of Fall:	2.5 mm (0.10") per hour or less
Moderate Rate of Fall:	2.6 mm - 7.5 mm (0.11" - 0.30") per hour
Heavy Rate of Fall:	7.6 mm (0.31") per hour or more

High intensity of rain often occurs during very short periods of time.

TABLE II: PERTINENT DATA FOR RAINSTORMS AND WEEPING TILE FLOW FOR NIAGARA FALLS #1

(1) DATE	(2) TOTAL RAINFALL	(3) DURATION OF RAIN		(4) AVERAGE INTENSITY	(5) ROOF VOLUME	(6) TOTAL FLOW	(7) DURATION OF FLOW	(8) TIME BETWEEN START OF RAIN AND START OF FLOW		(9) COMPUTED FLOW FOR 2.5 cm (1") CF RAIN	(10) NOTES *
	cm (inches)	hrs.	min.	cm/hr. (in/hr)	liters (IG)	liters (IG)	hrs.	hrs.	min.	liters (IG)	
Feb. 2, 1970	1.60 (0.63)	14	40	0.11 (0.04)	1680 (370)	10,000 (2,187)	25		19	15,900 (3,500)	1
Apr. 1,2, 1970	2.80 (1.10)	16	19	0.17 (0.07)	2960 (650)	9,600 (2,106)	34	2		8,700 (1,910)	1
June 17, 1970	1.12 (0.44)		30	2.24 (0.88)	1180 (260)	1,350 (297)	2		28	3,060 (675)	
July 9, 1970	1.42 (0.56)	2	42	0.53 (0.21)	1500 (330)	1,350 (297)	5.5	1	7	2,400 (530)	
Aug. 11, 1970	1.75 (0.69)	1	44	1.03 (0.41)	1860 (410)	2,940 (648)	6		22	4,250 (935)	2
Sept. 18, 1970	1.55 (0.61)	5	40	0.27 (0.11)	1630 (360)	1,840 (450)	14		30	3,040 (670)	
Oct. 12, 1970	2.60 (1.02)	12	15	0.21 (0.08)	2760 (610)	4,670 (1,026)	14	1	35	4,550 (1,000)	
Oct. 9, 1971	1.70 (0.67)	9	30	0.18 (0.07)	1800 (396)	1,560 (344)	15		8	2,340. (515)	3

* NOTES:
1 - Augmented by snowmelt
2 - High intensity at beginning of rainfall
3 - Soil still moist from previous rainfall

a rainfall of a small total amount. The effect of the first infiltrating 2.5 mm (0.1") is more noticeable. An average flow of 2700 to 3600 liters (600 to 800 IG) as a result of 25 mm (1") of rain seems a reasonable figure. The period in which the flow will persist is difficult to estimate.

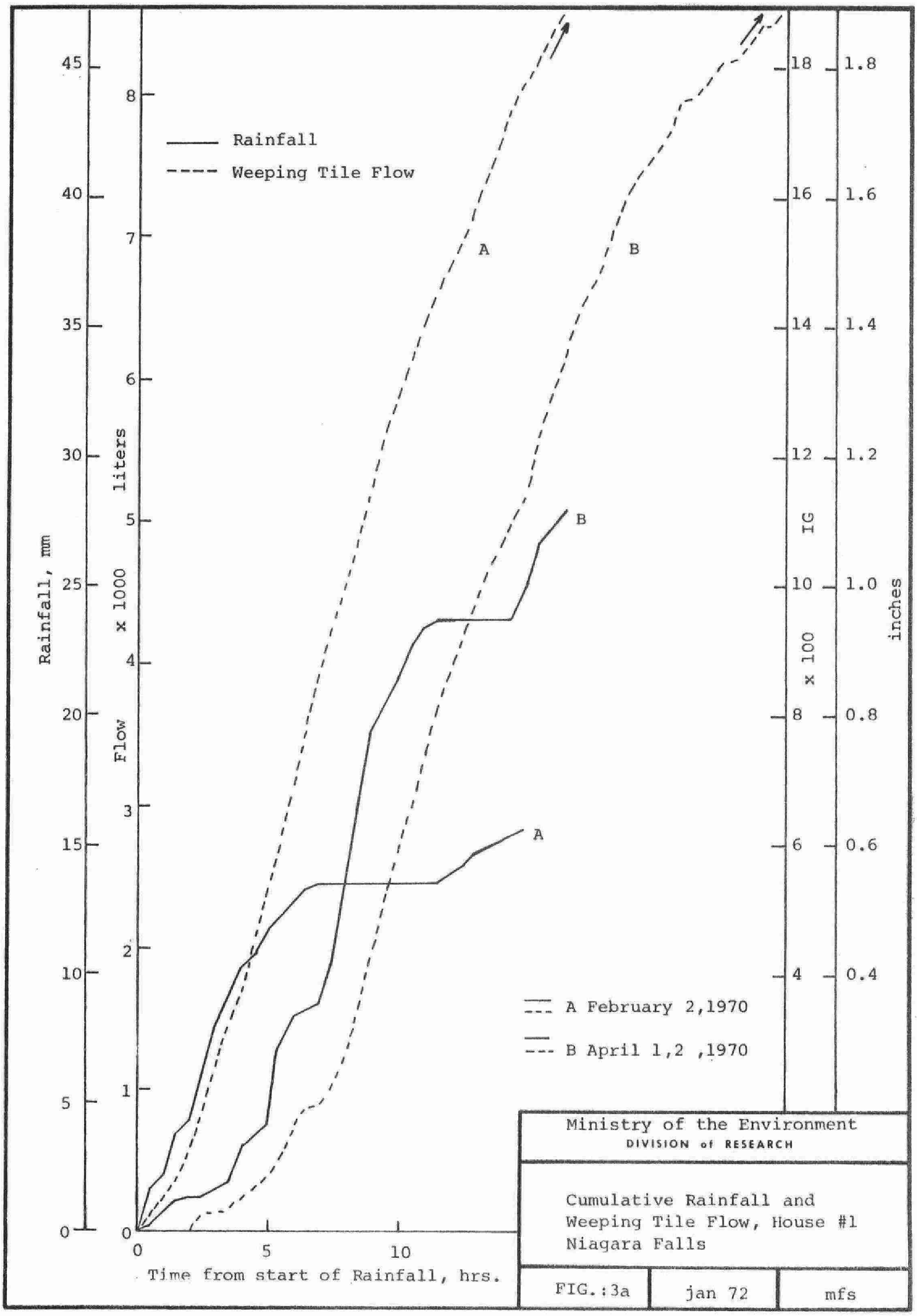
When rainfall is augmented by snowmelt the total flow is much higher but it is difficult to estimate the contribution from snowmelt. A concentrated rainfall tends to give a higher total flow than the same amount of rainfall spread over a long period of time. After each storm the flow continues for some time, then stops or becomes very irregular.

Figure 3 shows graphically some of the storms mentioned in Table II. The solid lines represent the rainfall records and the dashed lines the flow records with the time scale taken from the start of the rainfall.

Maximum hourly weeping tile flow measured at this site occurred on July 31, 1970:

> 1960 liters (432 IG) between 16:05 and 17:05 hrs. This means 33 liters per minute (7.2 IGPM), continuously for one hour;
>
> - rainfall within this hour: 0.32 cm (0.12")
> - rainfall in previous 15 min: 1.09 cm (0.43")

In the wintertime high flows can be expected after a rise in temperature, when there is still sufficient snow cover on the ground and the roof. Extremely high flows of this type occurred in the second half of February of 1971. Up to



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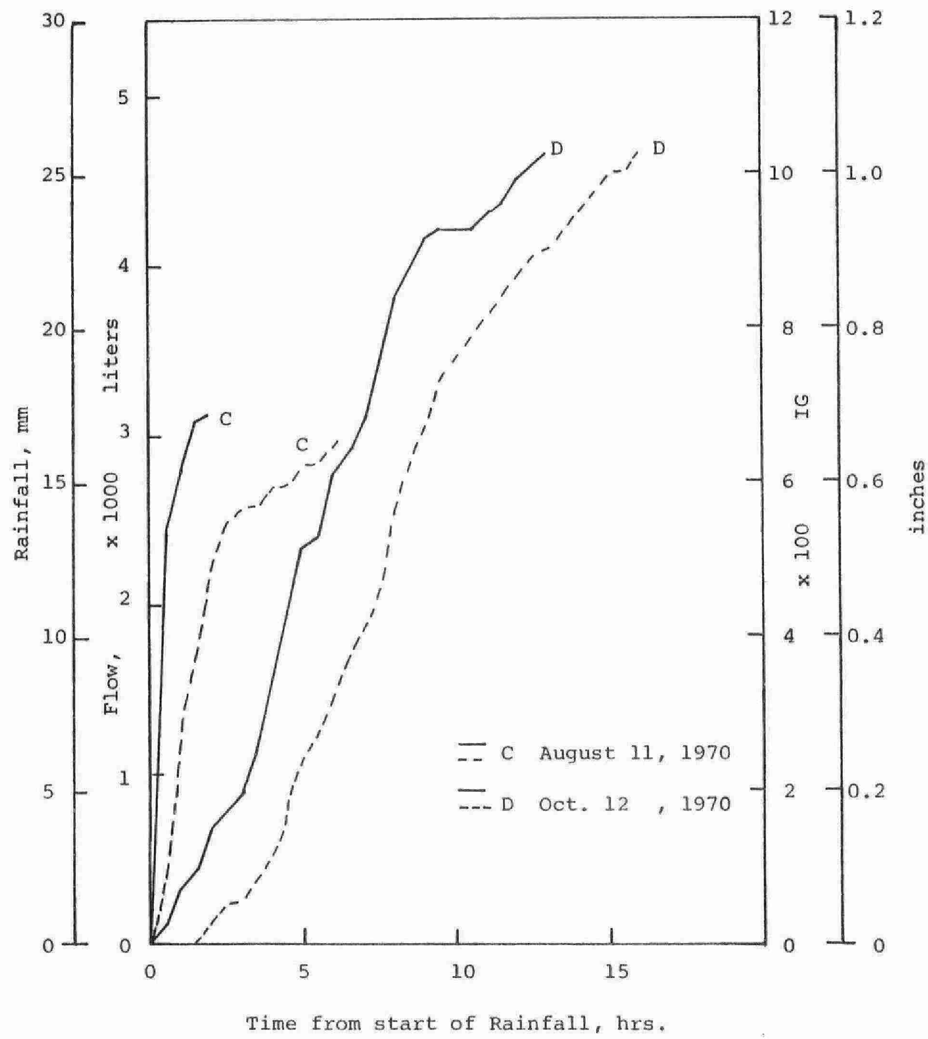
Cumulative Rainfall and Weeping Tile Flow, House #1 Niagara Falls

FIG.:3a | jan 72 | mfs



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Cumulative Rainfall and
Weeping Tile Flow, House #1
Niagara Falls

FIG.:3b	jan 72	mfs

as much as 20,400 liters (4500 IG) per day was measured on February 27, 1971. The Stamford-Niagara Falls weather report showed a maximum daily temperature of 43^{o}F on that day and 58^{o}F for the previous day after a long cold spell.

Overall observations show that contribution from this one house is considerable. There are no signs, as is often assumed, that the flow will diminish with the aging of the house. Based on two years of records an average yearly flow of 182,000 liters (40,000 IG) can be expected.

5.2 Niagara Falls #2

A very different flow pattern emerges here. Flow during the summer months occurs after a rainfall of at least 12.5 mm (0.5") and amounts to a maximum of 450 liters (100 IG). There is more flow during the melting period in the spring.

It is difficult to observe any general pattern in relation to flow as a result of rain and snowmelt. An estimate, based on a one year observation, of 32,000 liters (7000 IG) for total yearly flow is made.

5.3 Guelph

Similarly in this case, only very heavy rains are followed by a flow in the summertime. It might take some time to build up the 272 liters (60 IG) for one-minute operation time and small flows might have occurred in between heavy rainfalls. It is felt that the main amount of water is disposed

of through the roof drains into the storm sewer.

More flow occurred during December, January, March and April and probably February (the records are missing for that period) indicating that snowmelt can contribute considerably. April 1971 yielded about 13,500 liters (3000 IG). During the summer months a monthly average of 550 liters (120 IG) was measured. The estimated yearly flow is 30,000 liters (6500 IG).

5.4 Grimsby

A similar pattern exists here. In the summertime flows follow heavy rainstorms, but the amount is relatively small; 180 to 230 liters (40-50 IG) after a rainfall of 12.5 mm (0.5"). It appears that in the summer infiltrating rainwater cannot reach the weeping tile very quickly, probably due to its location inside the foundation. The time lag between start of rainfall and start of flow is considerable.

In December and Spring, as a result of snowmelt, a larger amount of flow was measured. The soil is more continuously saturated during these periods. In March 1971 a total of 14,000 liters (3100 IG) was measured. Yearly contribution is estimated to be 30,000 liters (6500 IG).

5.5 Smithville

Unfortunately there are no summer records available. Another problem occurred during the winter time when the pipe

to the creek froze and the sump pump was running continuously until the owner fixed this problem. A similar flow can be expected as in the previous cases and maybe even higher.

In March, when there was no freeze up problem, the flow totalled for the month 34,500 liters (7600 IG).

5.6 Ottawa Sites

From the information made available by the Division of Building Research of the National Research Council, for the Ottawa sites, it appears that the flow from weeping tile for the two houses is about the same during March and April of 1969. In general the house on low clay soil responds much more to rain fall and for a longer time flow will persist. Particularly in August there is practically no flow from the higher situated house, but the other house shows flows for every small rainfall.

For both houses a daily maximum was measured of about 13,600 liters (3000 IG) in April 1969, as a result of rain and snowmelt. Both houses will contribute considerably during the spring melt.

6. Quality Analyses of Sump Water

It is generally agreed that urban runoff, collected in storm sewers, forms a considerable polluting load when discharged into public water courses. Particularly the first part of a runoff carries many pollutants present on roofs and streets. Data presented for Cincinnati showed that from a relatively clean urban area the untreated runoff might be unacceptable to receiving water environments (8). In "Water Pollution Aspects of Urban Runoff" (9) it is suggested that from the viewpoint of collecting dirt present on roofs it is worth considering the disconnection of roof drains from the storm sewer and discharge them above soil to provide extra purification by the soil. This will, of course, cause extra loading on the weeping tile.

To gather information about the quality of water in the sumps a sampling program was started in March of 1971. Table III presents a summary of the sample analyses for the sumps in Niagara Falls, Grimsby and Smithville. For reason of comparison, figures are included for the effluent (primary) discharged by the Water Pollution Control Plant in Niagara Falls. Sump water figures compare very favourable with the effluent. Total solids are higher in the case of Niagara Falls #1 and Smithville, although suspended solids are lower. For all sumps Nitrate (NO_3) nitrogen is higher. This can be expected for groundwater.

The high coliform count in Niagara Falls #1 and #2 might be due to use of the sump for other reasons than just collecting weeping tile flow. It is certain that in the case of Niagara Falls #1 washing water also reached the sump on occasion. The quality of the sump water for the various cases surveyed is very high.

TABLE III Averages of Chemical Constituents for Four Sumps and Water Pollution Control Plant Effluent

(Figures are presented in mg per liter, except for pH and phenols)

		Niagara Falls # 1	Niagara Falls # 2	Grimsby	Smithville	WPCP Niagara Falls
BOD		9.0	7.0	4.5	0.5	80
COD		35	30	25	20	--
Solids	TOT.	830	350	410	2730	540
	SUSP.	35	35	25	10	65
	DISS.	795	315	385	2720	475
Phosphorus	TOT.	0.28	0.2	0.09	0.12	4.1
	SOL.	0.1	0.06	0.02	0.10	2.5
Nitrogen	NH_3	0.3	0.2	0.09	0.4	9.6
	TKJ	1.2	1.04	0.53	0.7	16.5
	NO_2	0.08	0.05	0.02	0.02	0.05
	NO_3	6.1	2.4	2.2	4.4	0.3
Chloride		37	9	2	--	--
Phenols (ppb)		3	3	4	5	--
pH		7.3 - 8.6	6.9 - 7.9	7.3 - 8.1	7.9 - 8.2	
No. of Samples		9	9	7	3	8

Coliform count per 100 ml.

	Niagara Falls # 1	Niagara Falls # 2	Grimsby	Smithville	WPCP Niagara Falls
Tot. Coliforms	90-188,000	24-13,700	<10	140	$1.1\text{-}45 \times 10^6$
Fec. Coliforms	10-22,800	4-100	< 4	< 4	

7. Conclusions

The houses where measurements were taken represent only a small section of building sites where weeping tile is used. It is unfortunate that not all conditions during building of the houses and laying of the weeping tile are known. Information about the location of the ground water table during measurements is also lacking, but it is reasonable to assume that the water table was below the foundation, since no continuous flow has been observed.

Taking these limitations into consideration, it is possible to draw the following general conclusions:

1. In all cases flow in the summertime is a direct result of rainfall. No signs of a continuous base flow are present. The amount of flow can vary widely from one location to another.
2. Downspouts discharging above soil seem to contribute a large amount of flow during a rainstorm in the summertime.
3. No direct relationship between amount of rainfall and amount of flow can be established for any of the sites.
4. During periods of snowmelt all houses yield a more or less continuous flow. Houses in clay soil tend to have the highest flow.
5. Based on the measurements taken, about half to two-thirds of the total yearly flow will take place during the period of spring melt (usually March and April).

6. The quality of the sump water is very high and does not require treatment before discharge into public watercourses.

8. General Discussion

Weeping tile, when discharged into the sanitary sewer, will cause an extra hydraulic loading for which the sewer is generally not designed. It will also cause problems for sewage treatment plants. A figure of 13,500 liters (3000 IG) during a month of spring melt is not unreasonable to expect from one house. This means for 15 houses per ha (6 houses per acre) an average flow of 4.62 liters per minute per ha (0.0011 cfs per acre) during that month or about 50% of the total design figure for infiltration often used. At the same time one can expect the infiltration itself to be at a maximum, therefore overloading of the sewer is soon achieved. During some periods, weeping tile alone can contribute the full design amount.

In the extreme case mentioned in this report, Niagara Falls #1, average yearly flow figures would show the following flows for 15 houses per ha. (6 houses per acre) with four persons per house:

average yearly sanitary flow:
$15 \times 4 \times 500 \times 365 \approx 11{,}000{,}000$ liters per ha.
(1.000.000 IG per acre)
average yearly weeping tile flow:
$15 \times 182{,}000 \approx 2{,}700{,}000$ liters per ha. (240,000 IG per acre)
total flow: 13,700,000 liters per ha. (1,240,000 IG per acre)

In this case weeping tile flow is about 20% of the total flow, a considerable amount when treatment costs are involved. In the other cases, mentioned in this report, weeping tile will contribute 6 to 10% of the yearly flow.

Since weeping tile contributes water of high quality which does not need treatment consideration should be given to means of avoiding discharge of weeping tile flow into sanitary sewers. Local conditions and economic factors will determine if it is feasible to divert the flow from weeping tiles.

Following are some considerations for areas to be developed and remedial measurements for existing areas:

1. Areas to be developed

   (a) When the area will have a storm sewer, downspouts and weeping tile should be connected to the storm sewer, even if this means installing a sump pump. It usually costs less to make connections during the building stage than having to provide them at some later date. Checks must be made to ensure that the proper connections are made.

   (b) When the area will not have a storm sewer, flow from weeping tile should be minimized by providing adequate surface drainage around the house. The houses should be built on a good gravel-sandbed and the weeping tile should be well above the ground-water table. Downspouts should have splash blocks or must be extended away from the house or discharged into ditches which collect run-off from the streets.

   It might be worthwhile to consider a temporary storage for weeping tile water through a cistern or storage tank from

which the water can be used later on for different purposes like lawn watering.

2. Existing Areas

In areas, where the sanitary sewer is often exposed to large flows, measurements should be taken to determine if weeping tile is the source and approximately how much is contributed or if infiltration or other reasons cause the large flows.

This can be done with a simple cumulative timing device for some selected sump pumps representative of the area. From the operation time of the sump pump per day or per week a flow estimate can be obtained. A program like this is underway in Sault Ste. Marie and more information can be expected from this city.

When weeping tile is considered to be a serious problem a further investigation will be necessary.

A downspout discharging into the soil is often a source of flow for the weeping tile. If a large number of this type of downspout is present a program can be started to require the discharge above soil or extension to drainage ditches. A program of this type was carried out successfully in Springfield, Ill.(10)

Sometimes in older areas stormsewers have been installed at a later date to provide adequate surface drainage.

If at the time of construction downspouts and weeping tile were not connected to the stormsewer, consideration should be given to do this. This, of course, may be a very costly program.

When weeping tile is found to contribute a relatively small amount of flow, continued discharge into the sanitary sewer might be the best solution economically.

Every remedial program should be well planned and, when carried out, its effectiveness in reducing flow from weeping tile into the sanitary sewer should be reported.

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LIST OF REFERENCES

1. Design and Construction of Sanitary and Storm Sewers, WPCF Manual of Practice No. 9, WPCF Washington DC, 20016, 1966.

2. City of Sault Ste. Marie Drainage Report, Proctor & Redfern, December 1965.

3. Webber, Lloyd W. and Nelson, Myron A., A Study of Storm Water Infiltration into Sanitary Sewers, Journal of Water Pollution Control Federation, Vol. 35, No. 6, Pg. 762-776.

4. Kirkham, Don, Seepage of Steady Rainfall through Soil into Drains, Transactions American Geophysical Union, Vol. 39, No. 5, Pg. 892-908.

5. Ferris, John G., A Quantitative Method for Determining Groundwater Characteristics for Drainage Design, Agricultural Engineering, June 1950, Pg. 285-291.

6. Dagan, Gedeon, Spacing of Drains by an Approximate Method, Journal of the Irrigation and Drainage Division, ASCE, March 1964, Pg. 41-66.

7. Extraneous Flow Study, Clark Creek and Torentorus I Drainage Areas City of Sault Ste. Marie, Proctor & Redfern, December 1967.

8. Viessman, Warren Jr., Assessing the Quality of Urban Drainage, Public Works, October 1969, Pg. 89-92.

9. Water Pollution Aspects of Urban Runoff Federal Water Pollution Control Administration U.S. Department of the Interior WP 20-15.

10. Peters, Gerald L. and Proemper, A. Paul, Reduction of Hydraulic Sewer Loading by Downspout Removal, Journal of Water Pollution Control Federation, Vol. 41, No. 1, Pg. 63-99.